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(71) Applicant *(for all designated States except US)*: NOTETRY LIMITED [GB/GB]; Kingsmead Mill, Little Somerford, Wiltshire SN15 5JN (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: MONTEIRO, Andre, Fraser [GB/GB]; High View, Stone Hill, Charlton, Malmesbury, Wiltshire SN16 9DX (GB). BURLINGTON, Geoffrey, Michael [GB/GB]; Podgwell Cottage, Sevenleaze Lane, Edge, Gloucestershire GL6 6NJ (GB). WELLS, Simon, Paul [GB/GB]; 11 Ashley Road, Bathford, Bath BA1 7TT (GB).

(74) Agent: SMITH, Gillian, Ruth; Dyson Research Limited, Intellectual Property Dept., Tetbury Hill, Malmesbury, Wiltshire SN16 0RP (GB).

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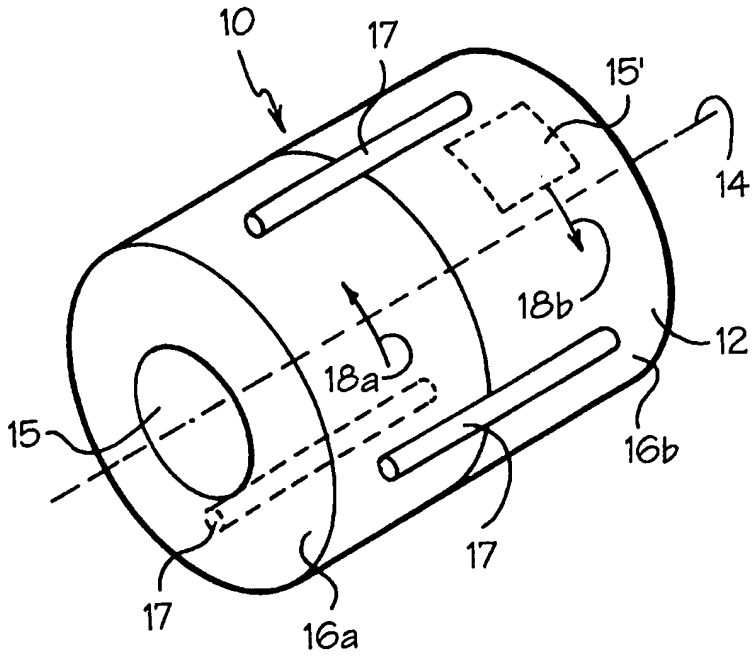
(54) Title: METHOD AND APPARATUS FOR CONTAINING AND AGITATING THE CONTENTS OF A CONTAINER

(57) Abstract

The invention provides apparatus for containing a plurality of articles (22) within a defined space and for causing agitation between the articles (22), comprising a drum (12) for receiving the articles (22) and for delimiting the defined space, and drive means (24a, 24b) for rotating the drum (12) so as to cause agitation between the articles (22), characterised in that the drum (12) comprises at least two rotatable portions (16a, 16b) and the drive means (24a, 24b) are capable of rotating the drum (12) in such a manner that relative rotation is produced between adjacent rotatable portions (16a, 16b). The invention also provides a method of containing and agitating a plurality of articles (22) within a defined space, comprising the steps of introducing the articles (22) to the interior of a drum (12) which delimits the defined space and which is rotatable by drive means (24a, 24b), and rotating the drum (12) so as to cause agitation between the articles (22), characterised in that, during at least part of the step of rotating the drum (12) so as to cause agitation between the articles (22), the drive means (24a, 24b) are operated in such a manner that relative rotation is produced between adjacent rotatable portions (16a, 16b) of the drum (12). This allows the contents of the drum (12) to be agitated at a significantly higher rate than in previous arrangements and is especially applicable to washing machines.



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Method and Apparatus for Containing and Agitating the Contents of a Container

The invention relates to a method and apparatus for containing a plurality of articles within a defined space and for causing agitation between the articles. The invention has application in any situation where articles are required to be treated by agitation for purposes as varied as cleaning, polishing, grinding, granulating, peeling and coating. Specifically, it is envisaged that the invention will have particular application in the laundry field in order to carry out cleaning (washing) or fabric treatment processes. Particularly, but not exclusively, the invention relates to an improved washing machine.

Conventional washing machines operate by agitating textile articles within a rotating drum in the presence of water and detergent so that dirt is released from the fibres of the textile articles into the water. The agitation is caused, in the case of front-loading washing machines, by the rotation of the drum about a generally horizontal axis so that the textile articles tumble over one another and rub against each other and against the walls of the drum. However, the rotational speed of the drum is limited because, if the speed is too high, the textile articles will merely be pressed under centrifugal forces against the interior walls of the drum. The articles then rotate with the drum and no agitation with respect to the drum or with respect to other articles is achieved. The amount of agitation which can be applied to the textile articles by front-loading washing machines is therefore limited. This means that, in order to achieve a specific standard of cleanliness, the machine must operate for a minimum period of time.

An object of the invention is to provide apparatus for containing a plurality of articles within a defined space and for causing agitation between the articles which is capable

of applying more agitation to the articles than known apparatus. A further object of the invention is to provide apparatus of the type described which is capable of agitating the articles inside a rotating drum to a higher degree of intensity than is currently possible. A further object of the invention is to provide a washing machine which is capable of washing textile articles more quickly than known washing machines. A still further object of the invention is to provide a washing machine which is capable of washing textile articles to a higher standard of cleanliness in a given time than known washing machines.

The invention provides apparatus for containing a plurality of articles within a defined space and for causing agitation between the articles, comprising a drum for receiving the articles and for delimiting the defined space, and drive means for rotating the drum so as to cause agitation between the articles, characterised in that the drum comprises at least two rotatable portions and the drive means are capable of rotating the drum in such a manner that relative rotation is produced between adjacent rotatable portions.

Preferably, the drive means are capable of rotating the rotatable portions at different speeds and/or in different directions. More preferably, the drive means are capable of rotating adjacent rotatable portions at different speeds in the same direction, at different speeds in opposite directions and/or at the same speed in opposite directions. The relative rotation between the adjacent rotatable portions prevents the articles from becoming adhered to the interior wall of the drum. Therefore, the rotational speed of the rotatable portions can be increased above that at which the articles would normally cease to be agitated. This means that the amount of agitation applied to the articles can be made more intense. The articles are therefore treated more intensively that they would be in conventional apparatus. If the apparatus is a washing machine, dirt is released from the textile articles at a higher rate than in known machines and therefore the cleaning process is either more thorough in a given time or else the desired

standard of cleanliness is achieved more quickly. Apparatus carrying out other processes will have similar advantages.

In a preferred embodiment, the drum consists of two essentially cylindrical rotatable portions. Advantageously, the rotatable portions are capable of being driven at the same speed in opposite directions. This maximises the agitation of the contents of the drum and, in the context of a washing machine, allows textile articles to be cleaned to a specific standard very quickly or, if desired, to a very high standard in a specific time. In alternative embodiments, the rotatable portions can be driven at different speeds in the same direction or at different speeds in opposite directions. It is also envisaged that it will be possible to achieve the same effect by retaining one rotatable portion stationary and rotating the other portion in either direction.

The invention also provides a method of containing and agitating a plurality of articles within a defined space, comprising the steps of introducing the articles to the interior of a drum which delimits the defined space and which is rotatable by drive means, and rotating the drum so as to cause agitation between the articles, characterised in that, during at least part of the step of rotating the drum so as to cause agitation between the articles, the drive means are operated in such a manner that relative rotation is produced between adjacent rotatable portions of the drum. The method according to the invention will have advantages similar to those of the apparatus according to the invention.

Other objects and advantages of the invention will become apparent from the following description of a number of preferred embodiments, all of which are given for the purposes of illustration only and are not intended to be limiting.

In the drawings:

Figure 1 is a schematic perspective view of apparatus according to a first embodiment of the invention:

Figure 2 is a longitudinal cross-sectional view of the apparatus of Figure 1 in use and forming part of a washing machine;

Figure 3a is a front view of the driving mechanism forming part of the apparatus of Figure 2;

Figure 3b is a side view of the driving mechanism of Figure 3a;

Figure 4 is a schematic perspective view of apparatus according to a second embodiment of the invention;

Figure 5 is a longitudinal cross-sectional view of the apparatus of Figure 4 in use and forming part of a washing machine;

Figures 6a, b and c are schematic perspective views, similar to Figure 1, of apparatus according to third, fourth and fifth embodiments of the invention;

Figure 7a is a front view of a seventh embodiment of the invention;

Figure 7b is a perspective view of the embodiment shown in Figure 7a in an open position;

Figure 8 is a perspective view of a ninth embodiment of the invention similar to the first embodiment but illustrating an alternative method of opening the drum;

Figure 9 is a longitudinal cross-section through a tenth embodiment of the invention;

Figure 10 is an exploded view of the rotating portions of the drum forming part of the embodiment shown in Figure 9:and

Figures 11a and 11b are side and plan views respectively of a paddle which forms part of the embodiment shown and illustrated in Figures 9 and 10.

Apparatus according to a first embodiment of the invention is illustrated in Figure 1. Essentially, the apparatus 10 consists of a cylindrical drum 12 mounted rotatably about an axis 14. The drum 12 is made up of two separate rotatable portions 16a, 16b, each consisting of a cylindrical wall and a circular end wall. Each circular end wall closes the respective rotatable portion 16a, 16b at one side, the open side facing the other respective rotatable portion 16b, 16a. One of the circular end walls has a door 15 incorporated therein. The door 15 is mounted in a conventional manner and will not be described any further here. It will be understood that this is only one way of providing access to the interior of the drum 12 and, as an alternative, a door 15' could alternatively be mounted in the cylindrical wall of one of the rotatable portions 16a, 16b. The rotatable portions 16a, 16b are individually mounted so as to be rotatable about the axis 14, for example by support bearings 17, and are each driven by a separate drive 24a, 24b (see Figures 2 and 3). The drives 24a, 24b are arranged and adapted so that each rotatable portion 16a, 16b can be rotated about the axis 14 at a speed or in a direction which is different from that of the other rotatable portion 16b, 16a. In the illustrated embodiment, the rotatable portion 16a can be rotated in the direction of arrow 18a at the same time that the rotatable portion 16b can be rotated at the same speed in the direction of arrow 18b.

Figure 2 shows the embodiment shown in Figure 1 as applied to the field of washing machines. The drum 12 is here located in a tub or tank 20 which also contains water and detergent. Textile articles 22 to be washed are contained within the drum 12 which has perforations (not shown) in order to allow water to flow into the drum 12 from the tank 20 and vice versa. There is no need for the rotatable portions 16a, 16b to be sealed against one another since the flow of water into and out from the drum 12 is

acceptable. Two separate drives 24a, 24b are positioned above the rotatable portions 16a, 16b in order to drive, independently of one another, the said rotatable portions 16a, 16b. The drives 24a. 24b will be described in more detail below.

When the drives 24a, 24b are activated, rotatable portion 16a is driven by drive 24a in the direction of arrow 18a and rotatable portion 16b is driven by drive 24b in the direction of arrow 18b. The rotatable portions 16a, 16b thus rotate about the axis 14 at the same speed but in opposite directions. The textile articles 22 contained within the drum 12 are agitated as the rotatable portions 16a, 16b rotate. The textile articles 22 are continually prevented from sticking to the cylindrical wall of either of the rotatable portions 16a, 16b by virtue of the fact that other articles are being rotated in the opposite direction by the other rotatable portion 16b, 16a. These other articles pull the said articles 22 from the wall of the rotatable portion 16a, 16b in which they are located. The speed of rotation of each rotatable portion of the apparatus can therefore be higher than could be achieved in known washing machines and this allows the achievable degree of agitation to be higher as well. Achieving a higher degree of agitation means that a desired degree of cleanliness can be achieved in a much shorter period of time than has previously been possible. Alternatively, a washing machine can now become capable of achieving a much higher standard of cleanliness in a given period of time than has previously been possible.

One of the drives 24a, 24b is illustrated in Figures 3a and 3b. It will be appreciated that the drives 24a, 24b illustrated in Figure 2 can be identical to one another. For this reason, only one drive is illustrated here. The illustrated drive means to be described below is not to be understood as being the only drive suitable for this purpose. Other drive means equally suitable for this application will be immediately apparent to a skilled reader. As can be seen from Figures 3a and 3b, the drive consists of a motor 30 having a shaft 32 carrying a first toothed wheel 34. A chain 36 or other linked member

engages the first toothed wheel 34 and also a second toothed wheel 38 fixed to a rotatable shaft 40 which is mounted to the casing or support structure of the washing machine by bearing means (not shown). The shaft 40 also carries a third toothed wheel 42, the teeth 44 of which are designed to engage with the links of a chain 46 or other linked member arranged around the periphery of one of the rotatable portions 16a, 16b. When the motor 30 is operated, the shaft 32 rotates causing the first toothed wheel 34 to rotate. This drives the chain 36 which causes the second toothed wheel 38 to rotate and, in turn, the third toothed wheel 42. Rotation of the third toothed wheel 42 forces the rotatable portion to which the drive is attached to rotate about the axis 14. The direction of rotation of the rotatable portion is determined by the direction of rotation of the motor, whereas the speed of rotation of the rotatable portion is determined not only by the speed of the motor but also by the configuration of the toothed wheels. The speed of rotataion of the rotatable portions can thus be selected at will.

It will be appreciated that the toothed wheels 34, 38, 42 and chains or linked members 36, 46 can be replaced where appropriate by pulleys and drive belts or other equivalent components. If a drive belt is used to drive the rotatable portion 16a, 16b itself, the drive belt may best be wrapped around a pulley located on or concentric with the axis 14 shown in Figure 1.

A second embodiment is illustrated in Figure 4. In this embodiment, the drum 120 is made up of three separate rotatable portions 160a, 160b, 160c. Each of the rotatable portions 160a, 160b, 160c has a cylindrical wall and the outermost portions 160a, 160c also have circular end walls so that the cylindrical drum 120 is essentially closed. A door 150 is provided in one of the end walls. Drive means similar to those shown in Figure 3 are provided (although not shown) in order to rotate each rotatable portion 160a, 160b. 160c about the axis 140. Outermost rotatable portions 160a and 160c are each rotatable in a first direction (see arrows 180a, 180c), whereas the central rotatable

portion 160b is rotatable in the opposite direction (see arrow 180b), but at the same speed.

The agitation provided to the contents of the drum 120 is once again significantly higher than would be achievable with a conventional washing machine. The rotation of adjacent rotatable portions 180a, 180b; 180b, 180c in opposite directions prevents the articles from becoming stuck to the cylindrical walls of the drum 120 simply because other articles, which are being rotated in the opposite direction, will not allow them to be carried around the drum 120. The other articles effectively drag the first articles off the walls and the agitation action is continued, even at high rotational speeds of the rotatable portions 180a, 180b, 180c.

When this arrangement is applied to a washing machine as shown in Figure 5, the agitation provided to the textile articles 220 contained within the drum 120 is significantly higher than that which can be achieved using known arrangements. As before, the drum 120 is located within a tank 200 containing water and detergent in order that the textile articles 220 are cleaned. In this arrangement, however, the drum 120 is mounted within the tank 200 about an inclined axis 140 instead of about a horizontal axis.

It will be appreciated that the embodiments described above can be adapted in order to achieve the same or similar effect, particularly with regard to the respective speeds and directions of the rotatable portions. Illustrations of alternative arrangements are given in Figures 6a, 6b and 6c. In Figure 6a, the rotatable portions 161a, 161b are shown rotating in the same direction but at different speeds by arrows 181a, 181b. In Figure 6b, the rotatable portions 162a, 162b are shown rotating at different speeds but in opposite directions by arrows 182a, 182b. In Figure 6c, one rotatable portion 163b is

shown as being held stationary (cross 183b) whilst the other rotatable portion 163a rotates (see arrow 183a). In all three cases, there is relative rotation between the rotatable portions 161a, 161b; 162a, 162b; 163a, 163b so that the effect of producing increased agitation of the contents of the drum 120 is achieved. It will be appreciated that the arrangements shown in Figure 6 are also applicable to drums consisting of three or even more rotatable portions.

A further alternative arrangement is illustrated in Figures 7a and 7b. In this arrangement, the washing machine 300 comprises a stationary tank 310 within which are supported, in any known manner, two rotatable portions 320a, 320b arranged on either side of a stationary portion 330. The stationary portion 330 incorporates a door 332 which is hingedly mounted about an axis 334 so as to be openable in order to allow articles to be introduced to the interior of the rotatable portions 320a, 320b. The stationary portion 330 is essentially triangular in side view as shown in Figure 7a. This allows the axes 312a, 312b about which the rotatable portions 320a, 320b are rotatable to be inclined to one another.

In use, the door 332 is opened in order to allow textile articles to be introduced to the interior of the drum 314, and the door 332 is then closed. During the washing cycle, the rotatable portions 320a, 320b are rotated about the axes 312a, 312b whilst the stationary portion 330 remains stationary. This produces relative motion between each rotatable portion 320a, 320b and the stationary portion 330, even when the rotatable portions 320a, 320b are rotated at the same speed and in the same direction. However, it is expected that a higher degree of agitation will be achieved if the rotatable portions 320a, 320b are rotated about their respective axes 312a, 312b at different speeds and/or in different directions. As before, the tank 310 provides the function of retaining the water and detergent in which the articles within the drum 314 are to be washed.

It will be appreciated that drums which consist of two or more essentially cyclindrical portions which are rotatable about a common axis can be opened to allow access without necessarily providing an openable door in a wall of the drum. Since the drum is made up of separate portions, it is possible to allow for one of those portions to move away from the adjacent portion in order to provide access. One way of achieving this is illustrated schematically in figure 8. The drum 414 comprises two rotatable portions 420a, 420b which are rotatable about a common axis 412. No door is provided in either the cylindrical walls or circular end walls of either rotatable portion 420a, 420b. Instead, one of the rotatable portions 420b is mounted so that, when the drum 414 is to be opened, the entire rotatable portion 420b is pivoted away from the other rotatable portion 420a. The open position is illustrated in dotted lines in Figure 8. In other respects, the construction of the embodiment illustrated in Figure 8 is similar to that of the embodiments illustrated and described above.

A further embodiment of a washing machine according to the invention is illustrated in Figure 9. The washing machine 500 has a tub 502 which surrounds and accommodates the drum 550. The tub 502 is watertight so as to contain and retain water and detergent therein. The tub 502 has an inlet 504 and an outlet 506 for the inlet and drainage of water and detergent respectively. A door 508 is provided in the front wall of the tub 502 so as to allow articles to be introduced to the interior of the drum 550. The apparatus thus far described is conventional and does not require to be described any further.

The drum 550 is mounted in a cantilever fashion on the wall of the tub 502 remote from the door 508. In accordance with the invention, the drum 550 is made up of two separate rotatable portions 560, 570. The first outer rotatable portion 560, is supported

on a hollow cylindrical shaft 561. An angular contact bearing 562 is located between the rear wall of the tub 502 and the hollow cylindrical shaft 561. The outer rotatable portion 560 is dimensioned so as to substantially fill the interior of the tub 502. More specifically, the outer rotatable portion 560 has a generally circular rear wall 563 extending from the hollow cylindrical shaft 561 towards the cylindrical wall of the tub 502, a generally cylindrical wall 564 extending generally parallel to the cylindrical walls of the tub 502 from the rear wall 563 towards the front wall of the tub 502, and a generally annular front face 565 extending from the cylindrical wall 564 towards the door 508. Sufficient clearance is allowed between the walls 563, 564, 565 of the outer rotatable portion 560 and the tub 502 to prevent the outer rotatable portion 560 from coming into contact with the tub 502 when the drum 550 is made to spin.

An inner cylindrical wall 566 is also provided on the interior of the cylindrical wall 564 of the outer rotatable portion 560. The inner cylindrical wall 566 extends from a point which is substantially midway between the rear wall 563 and the front face 565 to the front face 565. The space between the interior cylindrical wall 566 and the cylindrical wall 564 is hollow but, if desired, could be filled with a strengthening material. In this event, the strengthening material must be lightweight. The provision of parallel cylindrical walls 564, 566 in the portion of the outer rotatable portion 560 closest to the front face 565 provides strength to the whole of the outer rotatable portion 560 whilst reducing the internal diameter of the outer rotatable portion 560 in this region.

The inner rotatable portion 570 is supported on a central shaft 571, which in turn, is supported by deep groove bearings 572 located between the central shaft 571 and the hollow cylindrical shaft 561. The inner rotatable portion 570 essentially comprises a generally circular rear wall 573 extending from the central shaft 571 towards the cylindrical wall of the tub 502, and a cylindrical wall 574 extending from the periphery

of the rear wall 573 towards the front wall of the tub 502. The diameter of the cylindrical wall 574 of the inner rotatable portion 570 is substantially the same as the diameter of the inner cylindrical wall 566 of the outer rotatable portion 560. The cylindrical wall 574 of the inner rotatable portion 570 is dimensioned so that the distal end thereof approaches the end of the cylindrical wall 566 closest thereto. It is advantageous to keep the gap between these two cylindrical walls 574, 566 as small as possible. An annular sealing ring 567 is located on the cylindrical wall 564 of the outer cylindrical portion 560 immediately adjacent to the end of the inner cylindrical wall 566 closest to the inner cylindrical portion 570 so as to provide support for the distal end of the cylindrical wall 574 thereof.

The central shaft 571 and the hollow cylindrical shaft 561 are each driven separately by drives 580, 582. The means by which the shafts 561, 571 are driven is not critical but sufficient flexibility must be provided to allow the inner and outer rotational portions 570, 560 to be rotated in accordance with the method described below. Means for achieving this will be apparent to a skilled reader and do not form an essential part of the present invention.

An exploded illustration of the inner and outer rotatable portions 570, 560 is shown in Figure 10. As can be seen from Figures 9 and 10, the inner rotatable portion 570 is located inside the outer rotatable portion 560 so that the cylindrical wall 574 of the inner rotatable portion 570 is aligned with the inner cylindrical wall 566 of the outer rotatable portion. The central shaft 571 lies inside the hollow cylindrical shaft 561. Both of the inner and outer rotatable portions are preferably manufactured from stainless steel using manufacturing techniques which include clinching and welding, however the manner of manufacture is not essential to the present invention and it is envisaged that the rotatable portions could also be moulded from a suitable plastics material.

Also located within each of the rotatable portions 560, 570 are paddles 590. In the illustrated embodiment, three equi-angularly spaced paddles 590 are located on the cylindrical walls 574, 566 of each respective rotatable portion 570, 560. More or fewer paddles could be provided if desired. All of the paddles 590 are substantially identical and the shape thereof is illustrated in Figures 11a and 11b. As can be seen from Figure 11a, the paddle 590 has a height which reduces significantly from one end 592 towards the other end 594. In each case, the end 592 will be placed directly adjacent the circular wall or end face of the rotatable portion 560, 570 to which the paddle 590 is attached. In the case of paddles 590 attached to the outer rotatable portion 560, the end 592 will be directly adjacent the anular end face 565, and in the case of paddles 590 attached to the inner rotatable portion 570, the end 592 of the paddle 590 will be directly adjacent the rear wall 573. The upper surface 596 of the paddle 590 has an arcuate portion adjacent the end 592 and this arcuate portion can extend over as little as one third or as much as three quarters of the length of the paddle 590. In the illustrated embodiment, the arcuate portion extends over more than half of the length of the paddle 590, more specifically over approximately two thirds of the length thereof. The remainder of the upper edge 596 of the paddle 590 extends parallel to the lower surface 598 thereof. Seen in plan view, as shown in Figure 11b, the side edges 599 of the paddle 590 approach one another as they approach the distal end 594 of the paddle 590. Again, the side edges 599 are arcuate over part of their length, the remainder of the length thereof being parallel to one another.

The length of each paddle 590 is selected so that, when the paddles 590 are positioned on the cylindrical walls 566, 574 of the outer and inner rotatable portions 560, 570, the distal end 594 of each paddle 590 extends to a distance of between 10 and 30 millimeters from the gap between the cylindrical walls 566, 574. The shape of the upper surface 596 of each paddle 590 is selected so that the height of each paddle 590

adjacent the end 592 is sufficient to ensure that rotation of articles contained within the drum 550 is continuous when the drum is full or when heavy items are being washed. However, the height of the paddles 590 is sufficiently small, adjacent the distal end 594, to provide a gentle washing action for delicate articles when this is required. Suitable dimensions for a typical paddle for a washing machine are: a maximum height of substantially 50 millimeters, a minimum height of substantially 20 millimeters and a paddle length of substantially 190 millimeters.

The apparatus described above can be used in the following manner. Articles to be washed are placed inside the drum 550 and water is introduced via the inlet 504 in a known manner either at the required temperature or else at a reduced temperature in which case it is subsequently heated to the required temperature. At the start of the washing cycle detergent is introduced to the drum 550, once again in a known manner. The rotatable portions 560, 570 are then rotated by the drive means 580, 582 so that the speed and /or direction of rotation of one of the rotatable portions 560 is different from that of the other rotatable portion 570. The rotatable portions 560, 570 can be rotated at different speeds in the same direction, at the same speed in opposite directions, or at different speeds in opposite directions. Alternatively, one portion 560, 570 can be held stationary whilst the other portion 570, 560 rotates. In any event the speed of rotation of the rotating portions 570, 560 can be increased above the normal speed of rotation of washing machine drums during the washing cycle. In known machines this would not normally exceed 50 rpm. Even at speeds of rotation far in excess of 50 rpm, the contents of the drum 550 according to the invention do not stick to the wall of the drum and therefore the agitation applied to the said contents can be greatly increased.

When it is desired to rinse the articles contained within the drum 550, the washing water is drained from the drum 550 via the outlet 506 in a known manner and clean water is introduced thereto via the inlet 504. The rotatable portions 560, 570 continue

to be rotated in the same manner as that during washing in order to maintain a high level of agitation of the textile articles. After rinsing, the rotatable portions 560, 570 are rotated at the same speed and in the same direction in order to spin excess water from the textile articles in the usual way. The rotatable portions 560, 570 may be fixed together at this point by locking means (not shown) in order to ensure that there is little or no relative movement between the rotatable portions 560, 570 during spinning. If this fixing occurs, all but one of the drives 580, 582 may be shut off so that all or both portions 560, 570 are driven by a single drive. Alternatively, the drives 580, 582 may be arranged so that all or both rotatable portions 560, 570 are driven in the same direction and at the same speed during spinning with any minor differences in speed being kept under control merely by the presence of the contents of the drum 550. With the increased agitation of the contents of the drum 550, it is envisaged that the duration of a normal washing cycle currently lasting about 90 minutes can be reduced by about half, possibly more, without there being any reduction in the standard of cleanliness to which the articles are cleaned.

The apparatus of the invention is not limited to washing machines in its application and can be advantageously applied to any apparatus in which the contents of a container requires to be agitated to a high degree and where a shortening of the duration of the agitation would be an advantage. Other applications include polishing (eg of semi-precious stones), grinding, granulating, peeling (eg of foodstuffs such as potatoes) and coating. Furthermore, variations of the apparatus described above are intended to be included within the scope of the invention. For example, the shape of the drum need not be cylindrical and part-spherical and frusto-conical drums are envisaged. The rotatable portions may also be arranged so that they are not generally similar to one another. For example, in a cylindrical drum, one portion may make up the cylindrical wall of the drum whilst another portion may make up a circular end wall of the drum. These and other variations will be apparant to a skilled reader.

Claims:

1. Apparatus for containing a plurality of articles within a defined space and for causing agitation between the articles, comprising a drum for receiving the articles and for delimiting the defined space, and drive means for rotating the drum so as to cause agitation between the articles, characterised in that the drum comprises at least two rotatable portions and the drive means are capable of rotating the drum in such a manner that relative rotation is produced between adjacent rotatable portions.

2. Apparatus as claimed in claim 1, wherein the drive means are capable of rotating the rotatable portions at different speeds and/or in different directions.

3. Apparatus as claimed in claim 1 or 2, wherein the rotatable portions are rotatable about a common axis.

4. Apparatus as claimed in claim 3, wherein the axis is horizontal.

5. Apparatus as claimed in claim 3, wherein the axis is inclined to the vertical.

6. Apparatus as claimed in any one of the preceding claims, wherein the rotatable portions of the drum are each substantially cylindrical in shape.

7. Apparatus as claimed in any one of the preceding claims, wherein the rotatable portions of the drum each have substantially similar dimensions.

8. Apparatus as claimed in any one of the preceding claims, wherein the drum comprises two rotatable portions, each rotatable portion being generally cylindrical in shape.

9. Apparatus as claimed in any one of claims 1 to 7, wherein the drum comprises three rotatable portions, each rotatable portion being generally cylindrical in shape.

10. Apparatus as claimed in any one of claims 1 to 7, wherein the drum comprises two rotatable portions, each rotatable portion being generally frusto-conical in shape in shape.

11. Apparatus as claimed in any one of the preceding claims, wherein the drive means are capable of rotating adjacent rotatable portions at different speeds in the same direction.

12. Apparatus as claimed in any one of the preceding claims, wherein the drive means are capable of rotating adjacent rotatable portions at the same speed in opposite directions.

13. Apparatus as claimed in any one of the preceding claims, wherein the drive means are capable of rotating adjacent rotatable portions at different speeds in opposite directions.

14. Apparatus as claimed in any one of the preceding claims, wherein means are provided for holding one of the rotatable portions stationary whilst the or each other rotatable portion is rotated.

15. Apparatus as claimed in any one of the preceding claims, wherein means are provided for rotating the rotatable portions at the same speed and in the same direction.

16. Apparatus as claimed in any one of the preceding claims, wherein the drive means comprise a separate drive for each rotatable portion.

17. Apparatus as claimed in any one of the preceding claims, wherein a first of the rotatable portions is located inside a second rotatable portion.

18. Apparatus as claimed in claim 17, wherein the second rotatable portion has a recess portion in which the first rotatable portion is accommodated.

19. Apparatus as claimed in claim 18, wherein the second rotatable portion has an operative portion separate from the recess portion.

20. Apparatus as claimed in claim 19, wherein the diameter of the operative portion of the second rotatable portion is substantially the same as the diameter of the first rotatable portion.

21. Apparatus as claimed in any one of claims 17 to 20, wherein the first and second rotatable portions are mounted on concentric shafts.

22. Apparatus as claimed in any one of the preceding claims, wherein at least one of the rotatable portions has a plurality of paddles located on the interior surface thereof.

23. Apparatus as claimed in claim 22, wherein each paddle is shaped so that the height thereof decreases continuously over at least one third of the length of the paddle, measured in a direction parallel to the axis of the drum.

24. Apparatus as claimed in claim 23, wherein the height of each paddle decreases continuously over at least one half of the length thereof.

25. Apparatus as claimed in claim 24, wherein the height of each paddle decreases continuously over at least three quarters of the length thereof.

26. Apparatus as claimed in any one of claims 22 to 25, wherein the distal edge of each paddle is arcuate over at least one third of the length thereof, measured in a direction parallel to the axis of the drum.

27. Apparatus as claimed in claim 26, wherein the distal edge of each paddle is arcuate over at least one half of the length thereof.

28. Apparatus as claimed in claim 27, wherein the distal edge of each paddle is arcuate over at least three quarters of the length thereof.

29. Apparatus as claimed in any one of claims 22 to 28, wherein three paddles are provided on each rotatable portion.

30. Apparatus as claimed in any one of the preceding claims, wherein the apparatus forms part of a washing machine.

31. Apparatus for containing a plurality of articles within a defined space and for causing agitation between the said articles, substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

32. A method of containing and agitating a plurality of articles within a defined space, comprising the steps of introducing the articles to the interior of a drum which delimits the defined space and which is rotatable by drive means, and rotating the drum so as to cause agitation between the articles, characterised in that, during at least part of the step of rotating the drum so as to cause agitation between the articles, the drive means are operated in such a manner that relative rotation is produced between adjacent rotatable portions of the drum.

33. A method as claimed in claim 32, wherein the adjacent rotatable portions are rotated at different speeds and/or in different directions during at least part of the step of rotating the drum so as to cause agitation between the articles.

34. A method as claimed in claim 33, wherein the adjacent rotatable portions are rotated at the same speed in opposite directions during at least part of the step of rotating the drum so as to cause agitation between the articles.

35. A method as claimed in claim 33 or 34, wherein the rotatable portions are rotated at different speeds in the same direction during at least part of the step of rotating the drum so as to cause agitation between the articles.

36. A method as claimed in any one of claims 33 to 35, wherein the rotatable portions are rotated at different speeds in opposite directions during at least part of the step of rotating the drum so as to cause agitation between the articles.

37. A method as claimed in any one of claims 32 to 36, wherein at least one of the rotatable portions is held stationary whilst an adjacent rotatable portion is rotated during at least part of the step of rotating the drum so as to cause agitation between the articles.

38. A method as claimed in any one of claims 32 to 37, further comprising the step of rotating the rotatable portions of the drum at the same speed and in the same direction.

39. A method as claimed in any one of claims 32 to 38. utilising apparatus as claimed in any one of claims 1 to 31.

40. A method as claimed in any one of claims 32 to 39, wherein the method is adapted to wash laundry articles.

41. A method of containing and agitating a plurality of articles within a defined space substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

Fig. 1.

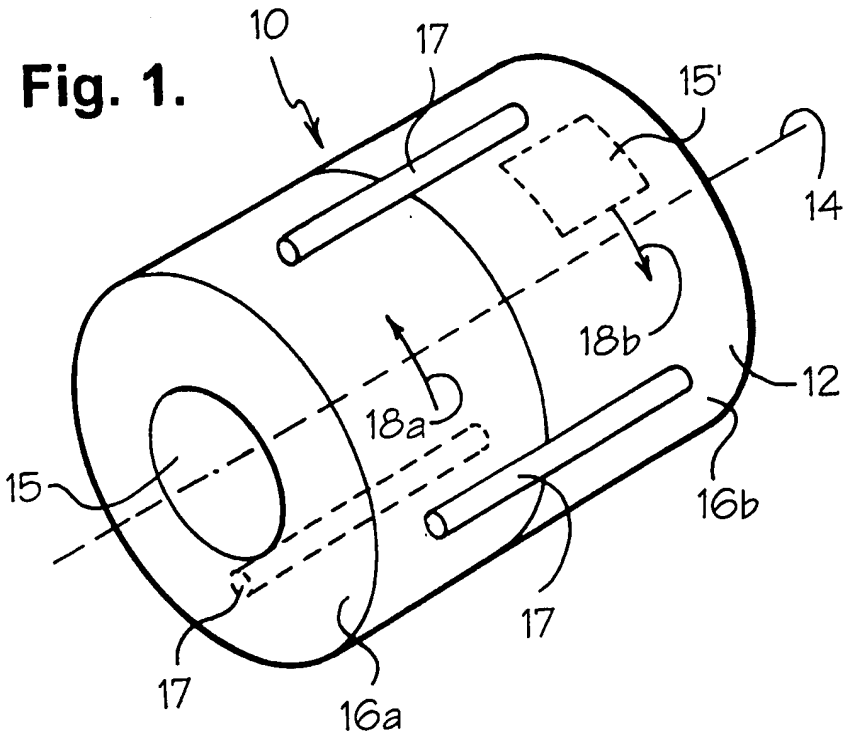
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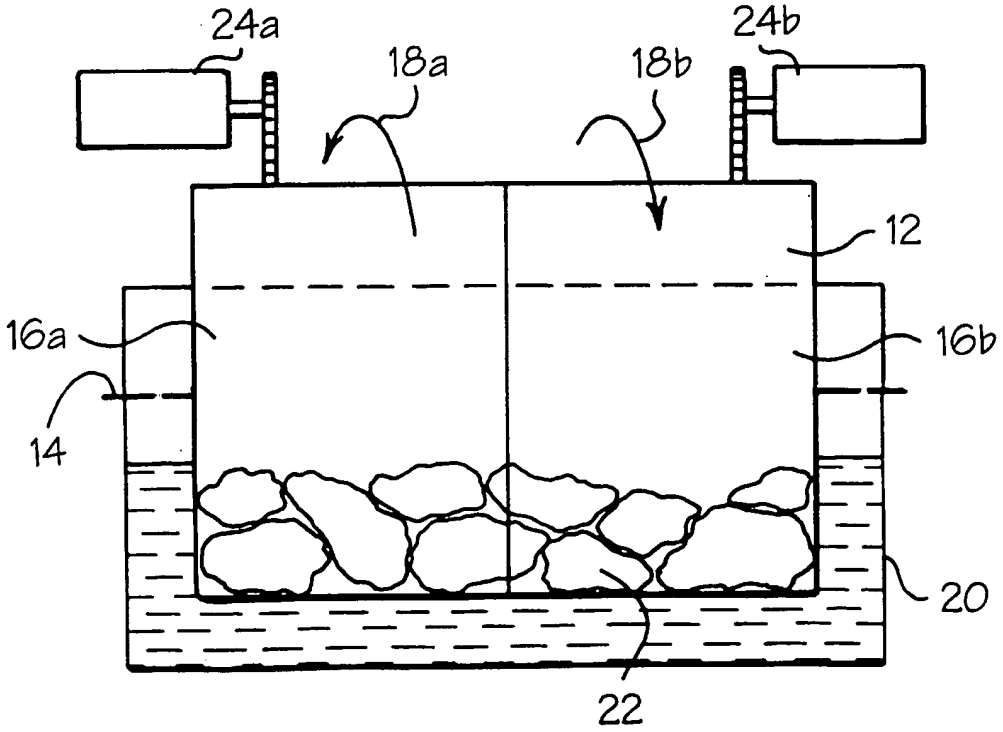
Fig. 2.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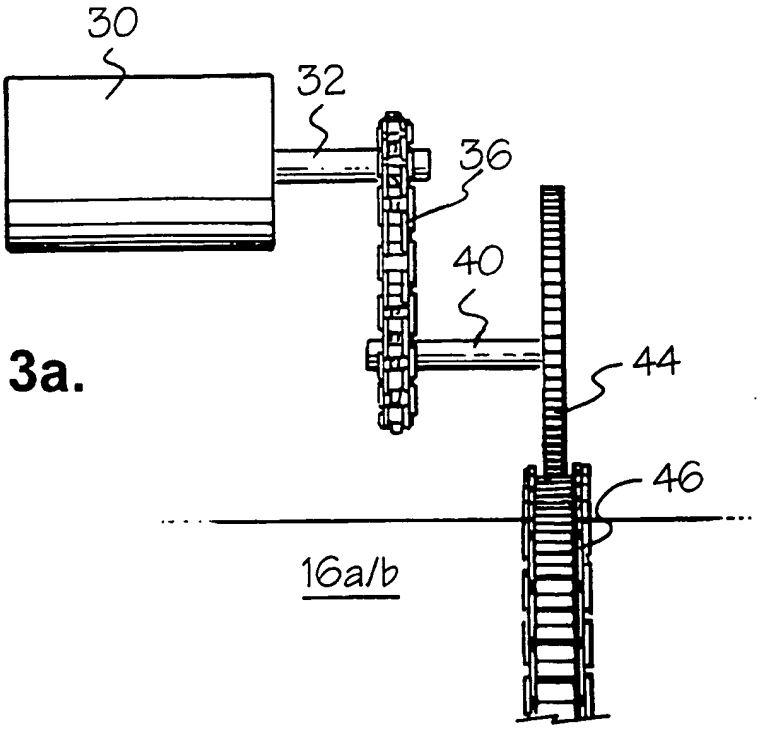


Fig. 3a.

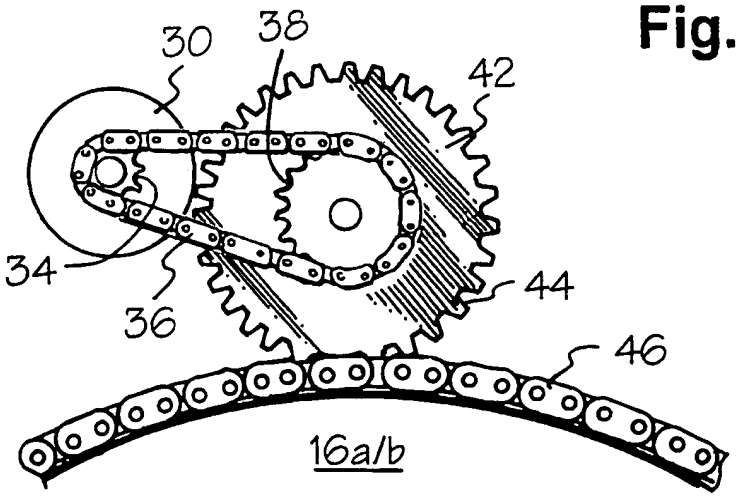


Fig. 3b.

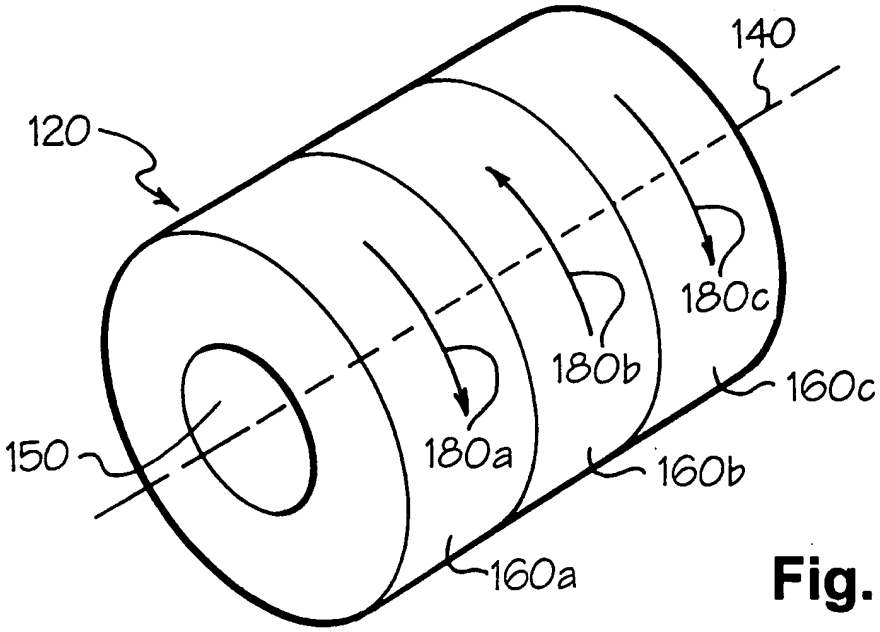
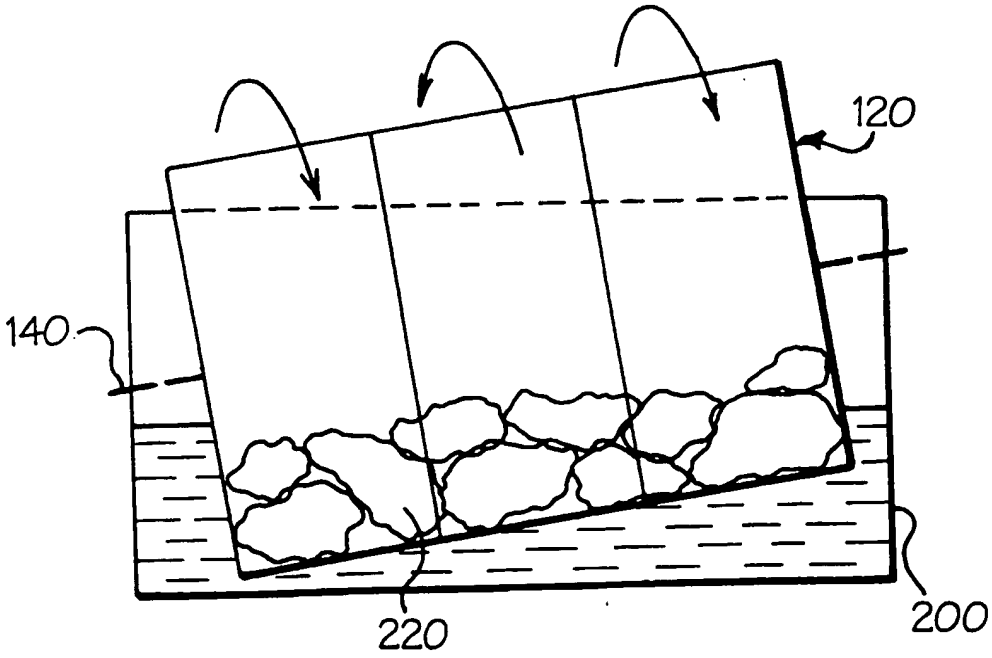


Fig. 4.

Fig. 5.



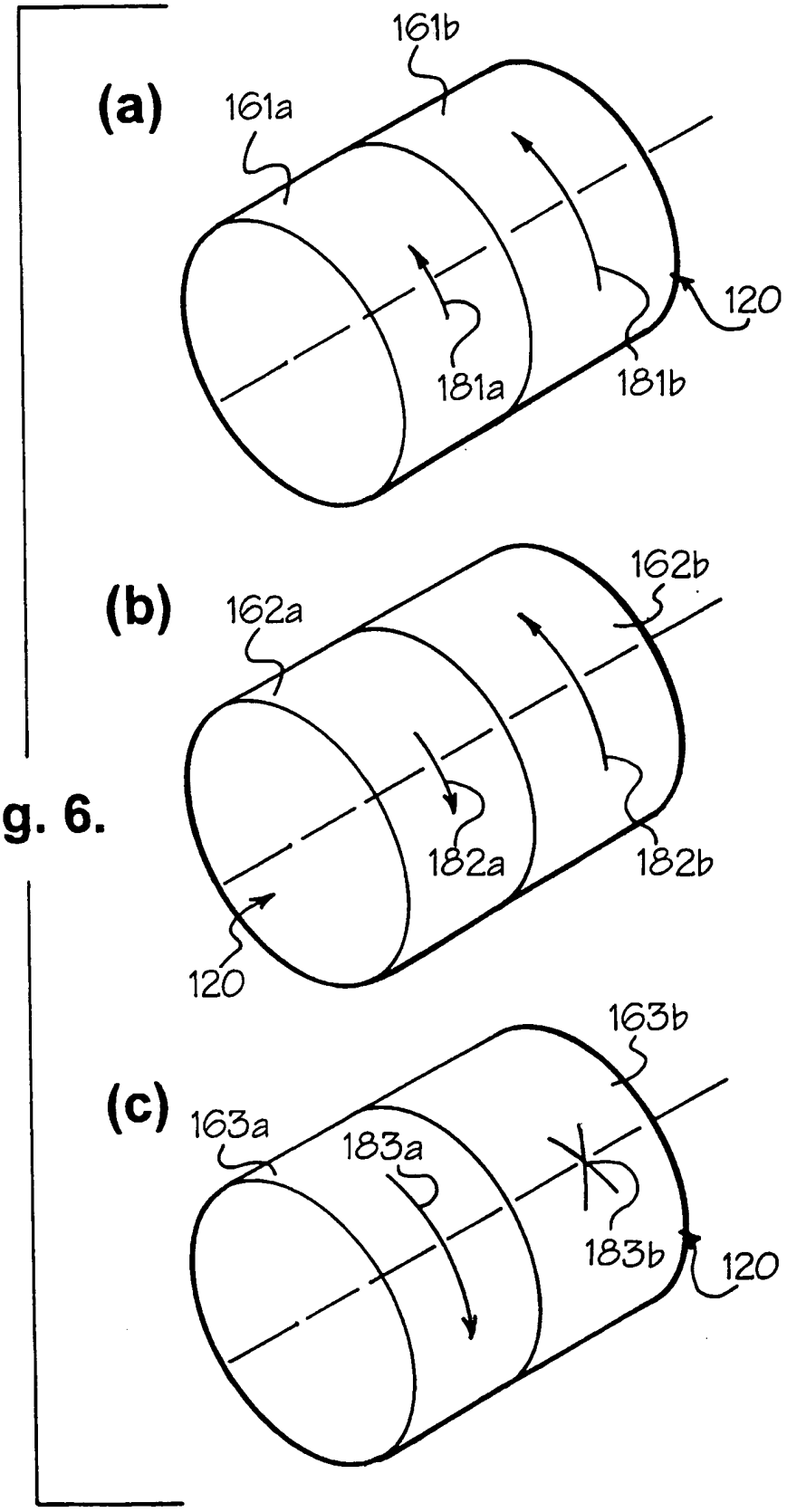

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Fig. 6.

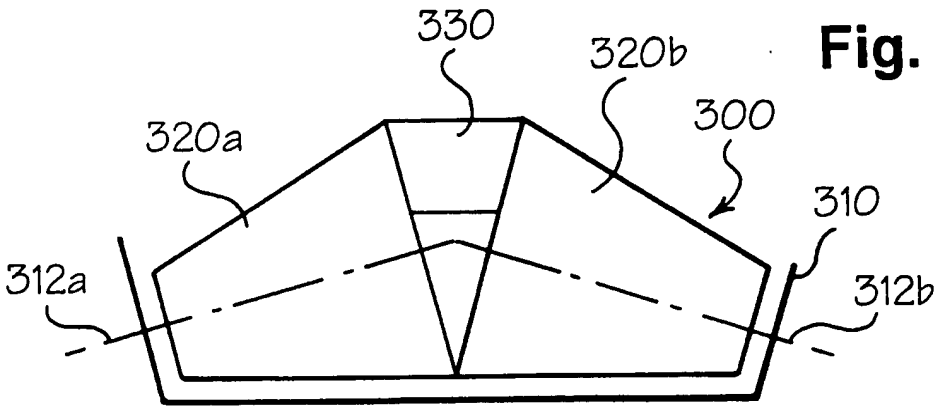


Fig. 7a.

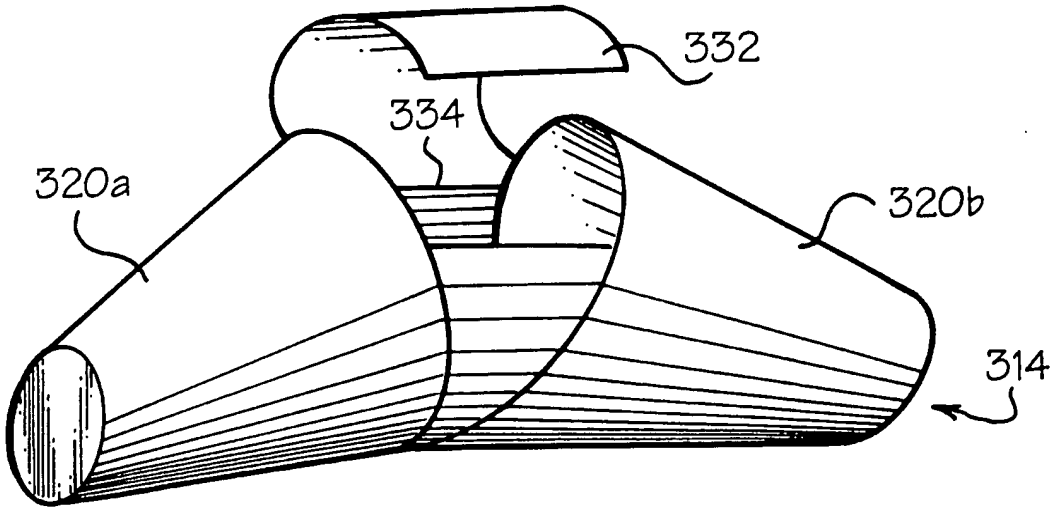


Fig. 7b.

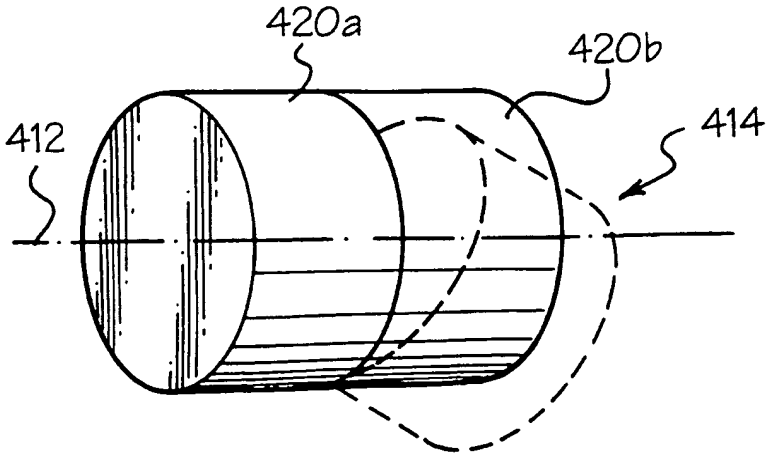
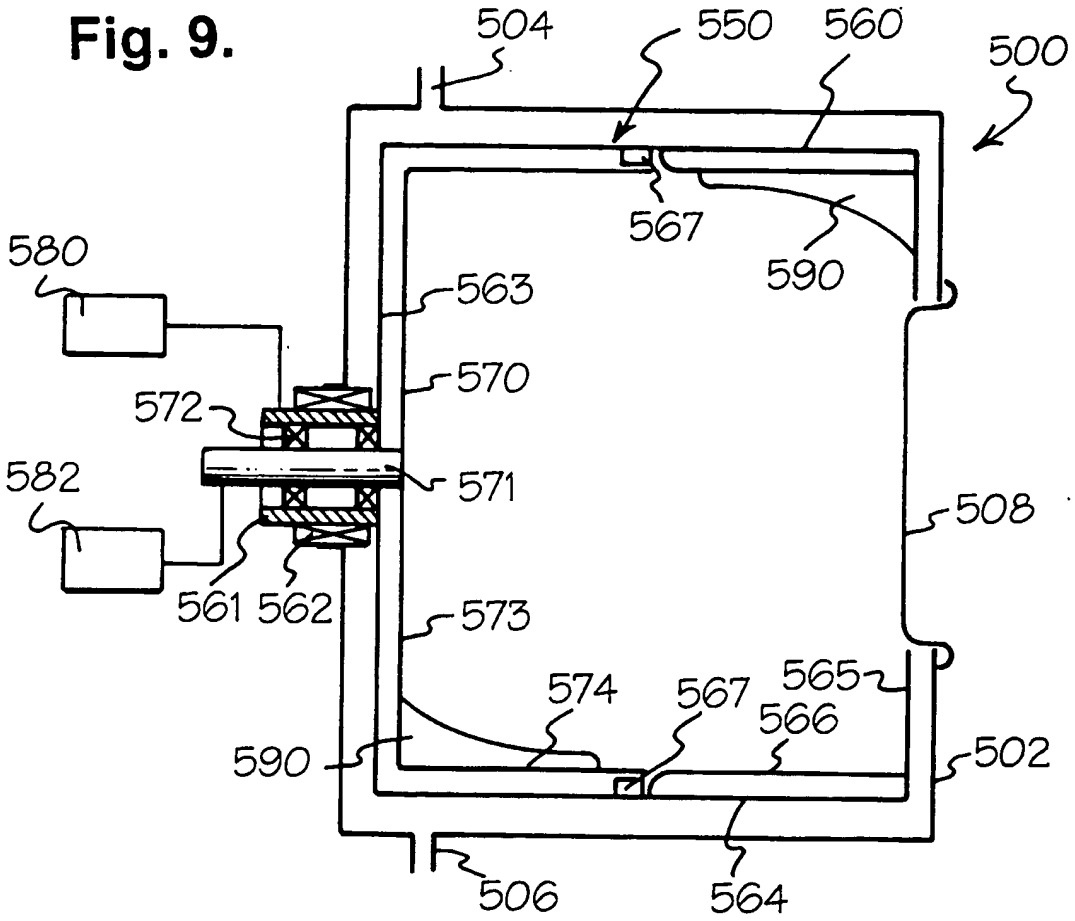


Fig. 8.

Fig. 9.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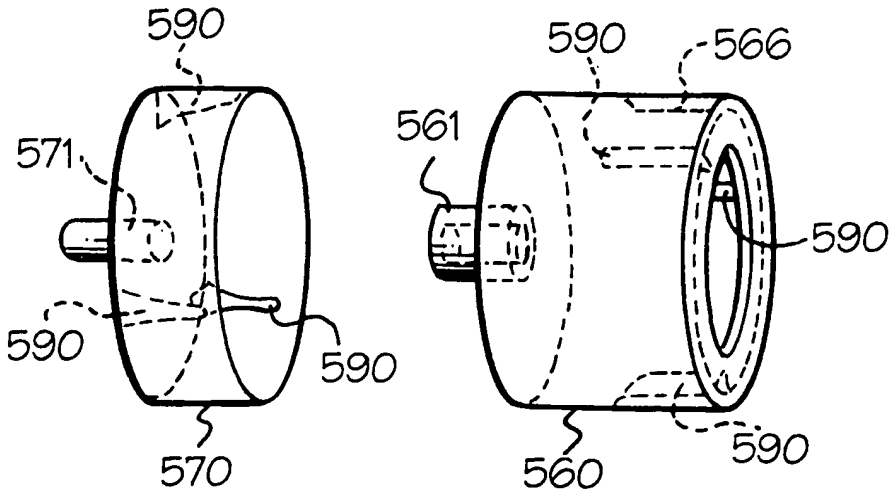
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Fig. 10.

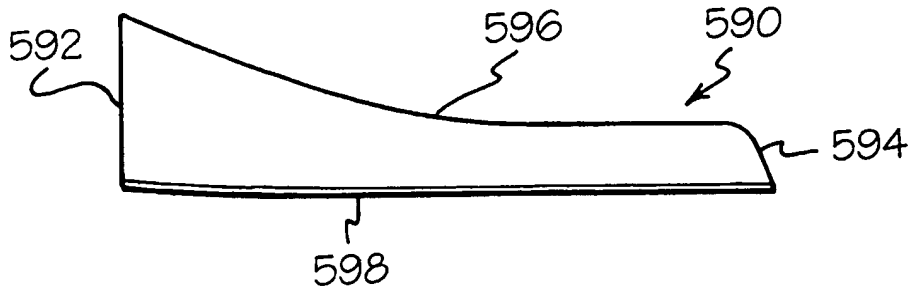

Fig. 11a.

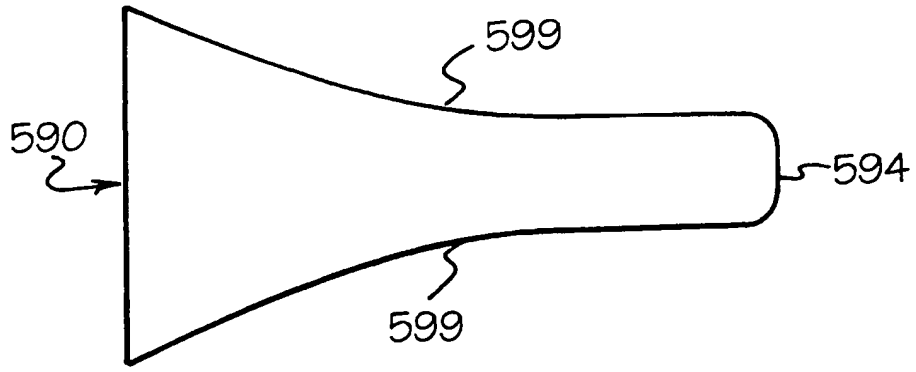

Fig. 11b.

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 99/01460

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D06F37/04 D06F21/04 D06F31/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 302 (C-0855), 2 August 1991 (1991-08-02) -& JP 03 111089 A (SHARP CORP), 10 May 1991 (1991-05-10) abstract	
A	EP 0 688 894 A (FORON WASCHGERAETE GMBH) 27 December 1995 (1995-12-27)	
A	US 3 035 430 A (ROTHENBERGER J) 22 May 1962 (1962-05-22)	
A	EP 0 509 931 A (MITSUBISHI HEAVY IND LTD) 21 October 1992 (1992-10-21)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 August 1999	13/08/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Debard, M

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern ...nal Application No
PCT/GB 99/01460

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